# ATTACHMENT 4: MUDDY CREEK WATERSHED MONITORING PLAN

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# 1. INTRODUCTION

This monitoring plan has been prepared to guide geomorphic, aquatic habitat, water quality and quantity and biological monitoring on the Muddy Creek watershed in the Continental Divide-Creston (CD-C) Natural Gas Development Project area. The CD-C Natural Gas Development Project is a natural gas field project that will be developed on public and private lands by BP America Production Company and others. The project area encompasses approximately 1.1 million acres and is located in an existing gas-producing area west of Rawlins, WY in Carbon and Sweetwater Counties. The CD-C project is an in-fill project with over 4,000 existing oil and gas wells and existing infrastructure. The selected alternative would include the development of an additional 8,950 gas wells as well as the construction of roads, pipelines, wellpads, and other supporting infrastructure.

A portion of the Muddy Creek watershed is located within the CD-C project area (**Figure O-1**). The Muddy Creek watershed is part of the Upper Colorado River Basin and is therefore subject to the Colorado River Basin Salinity Control Act. Muddy Creek has documented high levels of dissolved salts as well as elevated levels of suspended sediment. Reaches of Muddy Creek have been or are currently on the State's 303(d) list of impaired and threatened waters for sediment and habitat degradation. Monitoring should determine if activities associated with the CD-C project have an impact on Muddy Creek and its contribution of salinity to the Upper Colorado River.

The Muddy Creek drainage transitions from a cold water fish assemblage that supports Colorado River cutthroat trout, brook trout, and mountain suckers in the headwaters (upstream of the CD-C boundary), to a warm-water assemblage of native species including: bluehead sucker, flannelmouth sucker, and round tail chub within and downstream of the CD-C project area. Other species that occur within Muddy Creek include native speckled dace and non-native white suckers and creek chubs. There are four BLM sensitive fish species that are found in the Muddy Creek watershed: Roundtail Chub, Bluehead Sucker, Flannelmouth Sucker and Colorado River cutthroat trout.

Roundtail Chubs are found within the Green River drainage including portions of the Little Snake River drainage and can be found in the Muddy Creek watershed. Roundtail chubs occurring within Muddy Creek represent the most abundant population of this species known to occur within Wyoming (Baxter and Stone, 1995; Beatty, 2005; Bower, 2005). A recent status review indicated that the range of this species has been reduced roughly 55 percent from historical levels (Bezzerides and Bestgen, 2002). Causes for observed declines in the distribution of roundtail chubs include construction of mainstream dams, altered river flows, and changes in water temperatures (Bezzerides and Bestgen, 2002).

During the summer and fall of 2003 and 2004 within the upper Muddy Creek watershed, roundtail chubs were most abundant in areas containing deep pools and glides with rocky substrates. In addition, the abundance of roundtail chubs was positively associated with areas containing remnant pool habitats resulting from extensive stream drying (Bower, 2005). Extensive movements of adult roundtail chubs have not been documented within the Muddy Creek watershed (Compton, 2007), although movement of larvae and juveniles via drift has been documented in other portions of the Upper Colorado River Basin (Carter et al, 1986).

Bluehead suckers are present in the Little Snake, Green, Snake, and Bear River Basins in Wyoming (Baxter and Stone, 1995). This species is found in the Muddy Creek watershed (Baxter and Stone, 1995; Beatty, 2005; Bower, 2005). Bezzerides and Bestgen (2002) indicated that the range of this species has declined roughly 45 percent from historical levels. Causes for observed declines in distribution include construction of mainstream dams, altered river flows, changes in water temperatures, and hybridization with the white sucker (Bezzerides and Bestgen, 2002). Bluehead suckers within the upper Muddy Creek watershed represent the most abundant population of this species known within the Colorado River Basin of Wyoming (Bower, 2005).

Bluehead suckers were most abundant during the summer and fall of 2003 and 2004 in areas with rocky substrates (cobble-sized gravel) in close proximity to pool habitats within the upper Muddy Creek watershed. These areas are most common where pool-riffle sequences are present (Bower, 2005). Extensive movements of adult bluehead suckers during the spring were observed during 2005 within the Muddy Creek study area, presumably in association with spawning (Compton, 2007).

Flannelmouth Suckers are found primarily in the Yampa, Little Snake, Colorado, Green, and Gunnison River Basins and is the least abundant of the BLM sensitive species in Muddy Creek (Compton, 2007). Bezzeredes and Bestgen (2002) indicate that the range of this species has declined roughly 50 percent from historical levels. Similar to the causes identified for the decline of other native Colorado River Basin fishes, causes for observed declines in the distribution of flannelmouth suckers include construction of mainstream dams, altered river flows, changes in water temperatures, and hybridization with the white sucker (Bezzerides and Bestgen, 2002). Habitat features influencing the abundance of flannelmouth suckers during the summer and fall of 2003 and 2004 within the upper Muddy Creek watershed included rocky substrates as well as deep pools and runs (Bower, 2005).

Colorado River cutthroat trout were the only trout native to the Green River and Little Snake River drainages in Wyoming (Baxter and Stone, 1995). Historical records indicate that it was present in Muddy Creek in the mid-1800s. Historically, this subspecies inhabited clear-water tributaries of the Colorado River in Colorado, Utah, Wyoming, and probably also in New Mexico and Arizona (Behnke, 1992). This species now occupies only a fraction of its former range. Some of the most genetically "pure" of the remaining populations of this trout subspecies are found in Upper Muddy Creek (Baxter and Stone, 1995).

Colorado River cutthroat trout have been reintroduced into Littlefield Creek and other headwaters of Muddy Creek. The species is generally associated with steep, clear, cold-water streams around rocky areas, riffles, deep pools, and near or under overhanging banks and logs (Binns, 1977). Colorado River cutthroat trout have been extirpated from much of their original range through competition with brook trout, rainbow trout, and brown trout, and hybridization with rainbow trout (Binns, 1977).

Portions of the CD-C project area are also located within the Great Divide Basin (GDB) (**Figure O-1**). Although the GDB is a closed basin and has very few perennial waters, there is evidence that it is not hydrologically isolated via groundwater (Fisk, 1967). Geomorphic channel monitoring, habitat and biological monitoring will be limited in the GDB and monitoring efforts will be concentrated on water quality, water quantity and upland soil erosion monitoring.

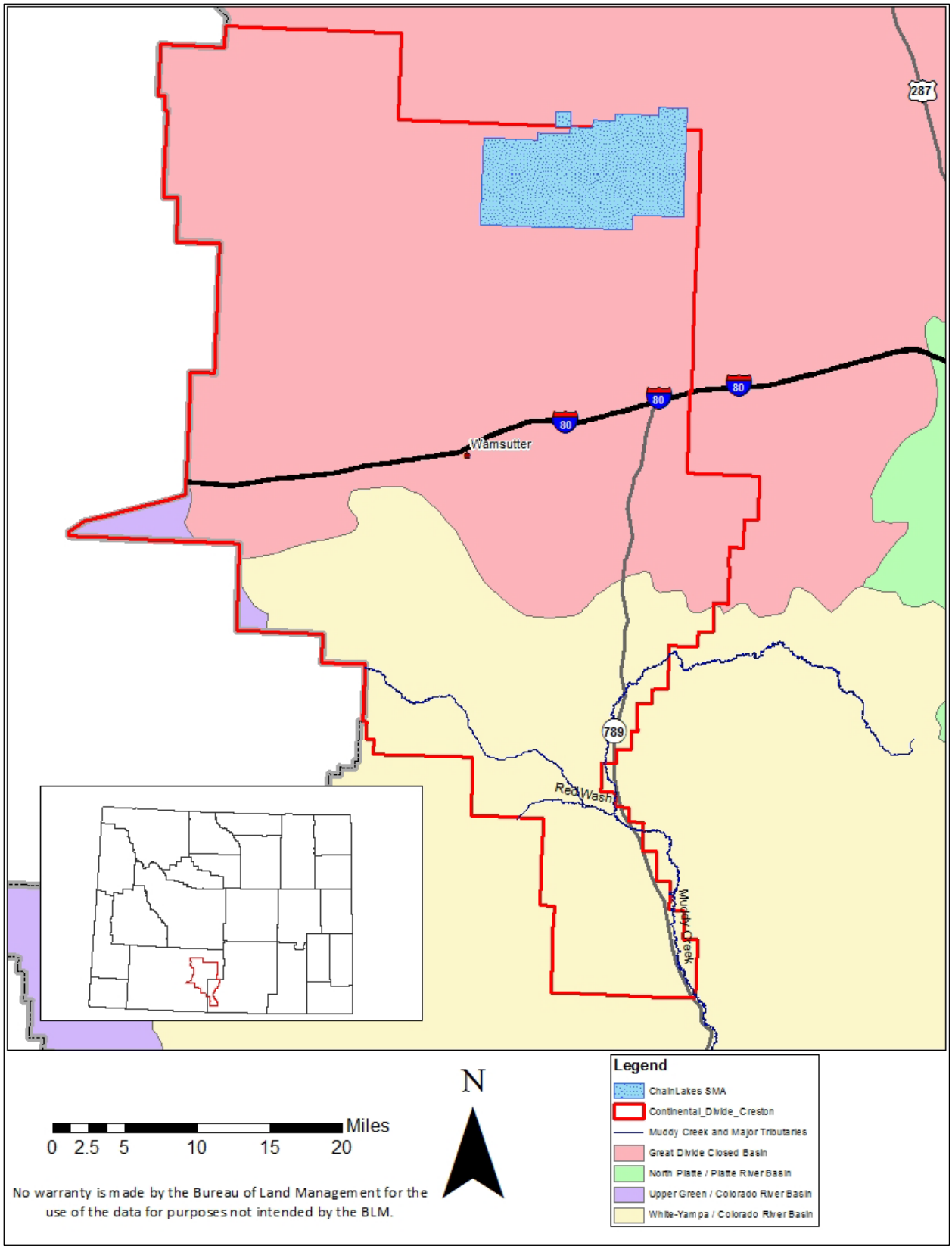


**Figure 4-1. CD-C project area and relevant watersheds.**

### 1.1 Background

The CD-C project was proposed by BP and other operators in 2005. The Bureau of Land Management (BLM) initiated scoping for an Environmental Impact Statement (EIS) in 2006. The Record of Decision was signed in 2014. Significant impacts to water resources were identified in the Final EIS and the objective of this plan is to measure potential effects on these resources as a result of natural gas development within the CD-C EIS boundary. Monitoring will be managed and completed by BLM personnel, with assistance from CD-C operators when possible.

### 1.2 Monitoring Objectives

The primary concerns with development activities are the modification of flow regimes, potential increase in sediment delivery and transport, and potential impacts to channel stability. Increases in stream sediment load could adversely affect sensitive fish populations and distribution. Aquatic habitat and riparian habitat could be degraded or lost.

To determine if the CD-C project has adverse impacts on water quality and sensitive fish populations, a multi-parameter approach that encompasses geomorphology, habitat features, hydrology, biologic indexes and water quality is recommended. The objectives of this monitoring effort include:

- Measurement of sediment delivery from eroding stream banks and eroding uplands.
- Measurement of habitat features and stream morphology
- Measurement of in-stream sediment concentrations and other water quality parameters
- Measurement of water quantity impacts
- Measurement of effectiveness of upland erosion controls

This monitoring plan focuses on Muddy Creek and its tributaries and the Chain Lakes area within or near the project boundary because these areas could potentially be directly affected by natural gas development.

## 2. GEOMORPHIC AND AQUATIC HABITAT MONITORING

This section describes the timing, location and methods for monitoring of geomorphic and aquatic habitat features in perennial drainage channels.

### 2.1 Study Reach Locations

The objective of geomorphic and aquatic habitat monitoring is to monitor potential impacts of development on the stream geomorphology and habitat features of perennial drainages, particularly Muddy Creek and its major tributaries. There are very few perennial drainages in the GDB and monitoring efforts in the GDB will focus on the lacustrine ecosystem of the Chain Lakes area. There may be some reaches of Muddy Creek that are well vegetated and relatively stable as well as some that are currently highly degraded. The impacts of development may scarcely change the quality of already degraded reaches, and it is also possible that the reaches in good condition may be stable enough to resist the potential impacts of development. It may be that marginally stable reaches will be the most sensitive to any future impacts. Therefore, it is recommended that stream conditions be monitored by selecting reaches that represent a range of stability and aquatic habitat conditions. Another criterion for reach selection will be the presence of suitable habitat for sensitive native non-game fish species. Habitat for the species of interest will be considered with the guidance of Wyoming Game and Fish Department (WGFD) personnel. Up to 6 study reaches will be identified in Muddy Creek that fit these criteria. The study reaches will be of sufficient length to capture the range of physical and habitat parameters typical of that stream type and may be up to 600 feet in length.

## 2.2 Monitoring Methods

Monitoring methods for geomorphology and aquatic habitat monitoring have been selected based on the goals of the study, input from other agencies and the BLM's experience with watershed assessments in other natural gas development areas. These methods include a Rosgen Level II survey, bed measurements, bank stability evaluations, and aquatic habitat feature measurements.

### 2.2.1 Rosgen Level II Survey

The assessment of selected study reaches will generally follow the methods of David Rosgen as described in Applied River Morphology (Rosgen, 1996); specifically, the Level II method will be followed. This method results in a stream classification according to the author's system but also develops many important stream parameters in the process. It requires surveys of longitudinal profiles as well as surveys of cross sections at riffles and pools. The purpose of this initial assessment is to determine the general geomorphic condition and what the probable evolution of the stream would be under natural conditions. Measurements to be taken at each study reach include:

- Cross sections across the floodplain at riffle and pool locations within the reach (up to six per study reach).
- Longitudinal profile of thalweg, water elevation, bankfull indicators, terraces, and bars.
- Riffle-pool spacing and pool lengths.
- Channel material size using the Wolman (1954) pebble count method.

These measurements will be supplemented by measurements of stream sinuosity, which will be determined from high resolution mapping rather than in the field.

Field measurements will be supplemented by photographs and a plan-view sketch of the features of each study reach. Important geomorphic features such as bed rock outcrops will be noted on the field sketches.

The Level II analysis uses the aforementioned field measurements to calculate a number of parameters:

- Channel slope
- Bankfull maximum depth
- Floodprone area width
- Bankfull surface width
- Bankfull mean depth
- Entrenchment ratio
- Width/depth ratio, and
- Dominate bed material ($D_{50}$ size)

In addition to the Level II analysis, for each pool, the residual depth will be calculated. Pool/riffle ratios will also be calculated based on the riffle spacing and pool length measurements. Benchmarks will be set locally on a local datum and will be located horizontally with a GPS receiver. Benchmarks will consist of iron rebar driven in the ground and guarded by a steel fence post.

### 2.2.2 Bed Measurements

Bed measurements are important for evaluating geomorphic stability as well as habitat. Variations in bed particle size over time may include aggradation or erosion of the bed material. The standard method for evaluating materials with course grained beds is the Wolman pebble count referred to above (Wolman, 1954) and is described in detail by Harrelson et al. (1994). Wolman pebble counts will be performed at three cross-sections within each study reach. The locations of the riffle reaches measured will be recorded with a GPS receiver. During data analysis, the cumulative size distribution for each pebble count will be plotted and the $D_{50}$ size (median size) calculated.

Embeddedness is an important aquatic habitat measurement because it measures the amount of siltation in a streambed. Normally, siltation is undesirable because it reduces habitat for benthic macroinvertebrates and spawning areas for fish. Embeddedness measures the amount of silt in a course grained (gravel, cobble, boulder) bed. The methods laid out by the Wyoming Department of Environmental Quality (WDEQ) in the *Manual of Standard Operating Procedures for Sample Collection and Analysis* (WDEQ, 2011) will be followed. Locations of embeddedness measurements will be documented with a GPS receiver.

### 2.2.3 Bank Stability

The annual remeasurement of the monumented cross-section for each study reach will indicate if banks are eroding. These monumented cross-sections will be selected at points where bank erosion is most likely to occur in the reach. To provide a more precise measurement of bank movement, erosion pins will be driven near the monumented cross sections at points most susceptible to bank erosion or collapse. The method used is described by Rosgen (2006).

### 2.2.4 Aquatic Habitat Features

Aquatic habitat features add complexity and heterogeneity to a stream, which are generally important to the health of the aquatic life. These habitat features are varied and can include large rocks in the channel, drops, large woody debris, overhanging banks, vegetation cover that extends over the channel and any other features that provide cover or other habitat for aquatic animal life. Also included as habitat features are drops and pools with adequate residual depths, which will be identified through the stream survey. It is not expected that the stream will contain significant amounts of large rock or large woody debris although, if found, these features will be noted on the field sketches. The most measurable aquatic habitat feature not addressed by the stream survey is expected to be vegetative cover that extends over the channel. In each study reach, overhanging vegetative cover will be approximately measured and its ratio to the bank length of the reach calculated.

## 2.3 Monitoring period and frequency

Baseline data collection is planned to occur during 2014 and 2015. Monitoring is initially planned to occur annually. It is likely that the monitoring protocols will be revised over time based on the results of data collected. Monitoring will take place in late summer during a period of low flow. Although low flow periods often exhibit the highest concentrations of dissolved constituents in water, higher sediment concentrations would be expected during spring high flows. However, the watershed is largely inaccessible during the high flow period because of snow and wet conditions. Other reasons for monitoring during the low flow period are that the geomorphic and aquatic habitat monitoring protocols are more easily and more accurately performed when flows are low.

Prior to baseline data collection, a reconnaissance level assessment of the watershed will be undertaken by agency personnel to document the present watershed condition and identify reaches where monitoring is most needed.

Each study reach will have 6 cross sections. Only one cross section, the “permanent cross section” will be surveyed annually. The remaining 5 will be measured every 5 years.

# 3. WATER QUALITY MONITORING

The objective of this surface monitoring program is to assess the water quality of Muddy Creek and its tributaries as well as the Chain Lakes wetland area within or near the CD-C Project Area and compile a data set beginning with baseline. The data set will be used to identify trends in water quality within the watershed potentially caused by oil and gas development and to determine the effectiveness of BMPs and

reclamation efforts. If the data show undesired effects on the water quality that could impact sensitive fish species or aquatic habitat, BMPs can be implemented and modified to reduce impacts associated with natural gas development.

### 3.1 Locations and Monitoring Frequency

Due to the difference in hydrology, monitoring methods will differ between the Muddy Creek watershed and the Chain Lakes wetland area. Muddy Creek is a tributary to the Little Snake River and ultimately the Colorado River. The Chain Lakes area is a unique alkaline wetland system that is located within the Great Divide Basin. Surface water within the Great Divide Basin is hydrologically isolated.

For the Muddy Creek watershed, sampling will be conducted annually during low-flow conditions at four locations within the upper portions of Muddy Creek within the project area; one upstream of the wetland complex near Dad, one immediately downstream of the wetland complex, one near the confluence of Red Wash and Muddy Creek and one on Muddy Creek near the southern end of the project area. The first surface water quality sampling activities are scheduled for 2014 and will be conducted in conjunction with the geomorphic and aquatic habitat monitoring activities.

In the Chain Lakes area, sampling will be conducted annually in the early summer. Most of the lakes go dry toward the end of the summer. Locations will be determined during the 2014 reconnaissance field trip.

### 3.2 Parameters and Methods

Field parameters will be measured by using a Datasonde/Surveyor 4 System with integrated parameters measurement equipment or approved equal. The following parameters will be measured at each sampling location as much towards the middle of the stream or lake as possible and recorded in the project field logbook: pH, temperature, dissolved oxygen (DO), turbidity, and specific conductance. All parameter measurement sensors will be calibrated at the factory before bringing the instrument to the field for use. The pH and DO sensors will be calibrated in the field prior to use on a daily basis and the calibration noted.

Surface water samples will be collected in laboratory supplied containers containing preservatives as appropriate for calcium, magnesium, sodium, potassium, chloride, sulfate and total alkalinity. These samples will be collected at each location by submerging the bottle by hand (dip) and allowing the container to fill as the container is brought up to the surface.

In addition, Total Suspended Solids (TSS) samples will be collected in laboratory supplied containers according to the Sample Collection and Treatment Section of Field Guidelines for Collection, Treatment, and Analysis of Water Samples, Montana District (1985). Appropriate pages of this method are included in Attachment B. To ensure representative TSS samples, integrated samples will be collected using the equal-discharge-increment (EDI) method along each channel cross section. This method requires that the field team determine at least five equal-discharge increments for each cross-section prior to commencing the sampling activities. The total flow in the creek will first be determined using the equal-width-increment (EWI) method which will be used to determine the location of each flow increment. All measurements will be recorded in the field logbook. Depending on the depths of the lakes sampled in the Chain Lakes area, depth integrated samples will be taken.

## 4. BIOLOGICAL MONITORING

The objective of the biological component is to measure species richness through time using fisheries sampling. The fisheries component will be sampled using Robert Bramblett's Integrated Biotic Indices (IBI) (Bramblett et al, 2005).

### Methods

Three total sites will be chosen on Lower Muddy Creek, both within the CD-C boundary and outside (downstream) the CD-C boundary. Sites will be sampled annually for three years to create a baseline. Once baseline sampling is complete, sites will be re-surveyed once every three years during the 15-20 year development stage and every five years once development is complete. The Fish Sampling Protocol is described below.

Each sampling site will be 300 meters in length. The sites will be sampled using a seine (net) or backpack electrofishing. Sampling technique will be determined on a site specific basis. When stream sections are flowing or continuous, block nets will be used on both the upstream and downstream starting and stopping points to create a 'closed' section.

Once the 300 meters has been sampled the fish will be identified, a small subset of 20 for each species will be measured and all fish will be counted. Any fish that cannot be identified will be vouchered and preserved for further analysis.

## 5. REPORTING

After completion of field activities and receipt and quality control of laboratory data, an annual data report will be prepared. The report for the initial monitoring year will also include information on the watershed and initial stream assessment information that will not be collected in future years. This information includes a description of the watershed and geomorphic stream classifications. The initial report will include interpretation of the assessment data such as determining Rosgen stream types, pool/riffle ratios, and bankfull flows. Monitoring data will be summarized in tabular form and a description of the existing conditions to the monitoring program will be presented.

In the following years, the annual report will summarize data collected in that year, compare it the previous year's data and note any significant changes in conditions. Recommendations for possible modifications of BMPs and operations in the watershed will be presented as well as recommendations for modifications to the monitoring program. The reports will contain appendices presenting field data sheets, sketches, site photos and laboratory data sheets.

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